EARTH OBSERVATION SYMPOSIUM (B1)
Future Earth Observation Systems (2)

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THE POLE-SITTER MISSION CONCEPT: AN OVERVIEW OF RECENT DEVELOPMENTS AND POSSIBLE FUTURE APPLICATIONS

Abstract

The pole-sitter is a highly novel mission concept that employs a spacecraft stationary above one of the Earth's poles. This idea is appealing, as it is the only platform that can provide continuous, real-time monitoring of high-latitude and polar regions, with a full hemispheric view, as well as direct-link telecommunications, where conventional geostationary platforms are not in sight, and polar orbiting platforms can only provide a narrow swath of images on each polar pass. It is known that this class of mission could be enabled by means of continuous low-thrust propulsion, which counterbalances gravity and maintains the spacecraft in an artificial equilibrium position or along a non-Keplerian orbit. Different concepts have been proposed in the literature, ranging from the exploitation of displaced Lagrangian points $L1$ and $L2$ in the Earth-Sun system for high-latitude observation, to static polar observers that hover constantly along the Earth's polar axis. In all cases, the main drawback is the relatively large distance of the spacecraft from the Earth. This imposes requirements and limitations for the payload, for example in terms of pointing accuracy, imaging resolution and available bandwidth. However, similar issues arise with imagers proposed for the classical $L1$ point such as the Deep Space Climate Observatory (DSCOVR) mission. Starting from the original concept of the "statite" proposed by R. Forward, through other proposed concepts, until recent new findings on the pole-sitter mission by means of hybrid solar sail and solar electric propulsion (SEP), this paper will present an overview of the current state of the art for the pole-sitter mission concept. Possible feasible applications for the mid- to long-term timeframe will be proposed and discussed, including real-time observation of the poles for climate science at moderate resolution (for polar weather), ice pack monitoring for ship routing, direct-link telecommunication with high-latitude regions (such as facilities in Antarctica and future oil and gas exploration in the Arctic). The paper will cover the spacecraft orbital dynamics, involving a trade-off of the orbit characteristics and propulsion type (solar sail, SEP, or a hybridisation of the two), mass budgets, and an analysis of the payload requirements and performances for a range of different possible mission scenarios. Advantages and drawbacks of each option will be compared against more conventional types of missions, e.g. Molniya orbits and Sun-synchronous polar orbiters.